Determination of Mineralogical Contents of a Bangle Shard from an Indus Valley Settlement through X-ray Diffraction Analysis

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The mineralogical make up of clay used in a bangle shard (Fig. 1) collected from Harrappa, an Indus Valley settlement now located in Pakistan has been determined using XRD testing carried out on 'Philips X'Pert PRO X-ray diffractometer' available in Geoscience Advance Research Laboratories (a facility of Geological Survey of Pakistan) in Islamabad. XRD analysis shows that the mineralogical make up includes montmorillonite ($(Na,Ca)_{0.33}(Al,Mg)_2(Si_4O_{10})(OH)_2 \cdot nH_2O$), gypsum ($CaSO_4 \cdot 2H_2O$), and quartz ($SiO_2$). The X-ray diffractogram was developed using PW3050/60 goniometer. The generator settings were 30 mA/40 kV with CuKα radiation of λ = 1.5406 Å. Continuous scanning was carried out from 10.01 as 2θ start position to 79.99 as 2θ end position, with a step size of 0.02 and step time of 1 s.

Fig. 1 Bangle shard photographed with Pakistani one rupee coin as reference. Diameter: 0.95-1 cm, length: 5.65 cm or about 2/5th of the complete bangle.

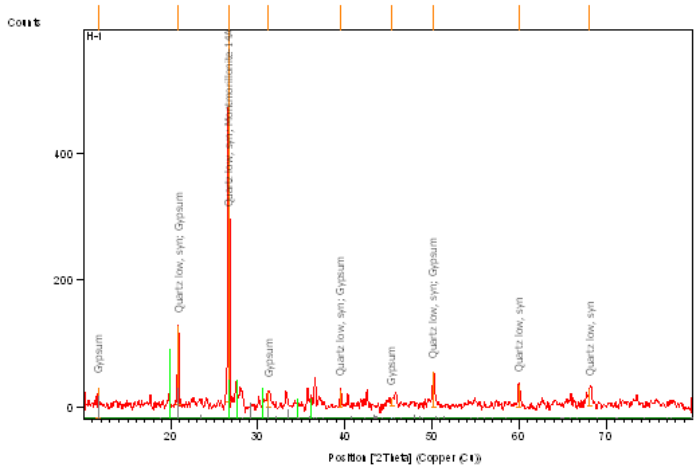
XRD Testing Parameters and Results

1(a) Anchor Scan Parameters

Dataset Name:	H-1
File Name:	C:\X'Pert Data\2011\May\H-1.xrdml
Comment:	Material analysis for universities
	Configuration=Flat Sample Stage, Owner=User-1, Creation date=2/5/2008 9:32:46 AM
	Goniometer=PW3050/60 (Theta/Theta); Minimum step size 2Theta:0.001; Minimum step size Omega:0.001
	Sample stage=PW3071/xx Bracket

	Diffractometer system=XPERT-PRO
	Measurement program=material analysis, Owner=User-1, Creation date=3/28/2008 10:27:40 AM
	synthetic material
Measurement Date / Time:	5/6/2011 9:25:21 PM
Operator:	Geoscience
Raw Data Origin:	XRD measurement (*.XRDML)
Scan Axis:	Gonio
Start Position [°2Th.]:	10.0100
End Position [°2Th.]:	79.9900
Step Size [°2Th.]:	0.0200
Scan Step Time [s]:	1.0000
Scan Type:	Continuous
Offset [°2Th.]:	0.0000
Divergence Slit Type:	Fixed
Divergence Slit Size [°]:	0.5000
Specimen Length [mm]:	10.00
Receiving Slit Size [mm]:	0.1000
Measurement Temperature [°C]:	25.00
Anode Material:	Cu
K-Alpha1 [Å]:	1.54060
K-Alpha2 [Å]:	1.54443
K-Beta [Å]:	1.39225
K-A2 / K-A1 Ratio:	0.50000
Generator Settings:	30 mA, 40 kV
Diffractometer Type:	0000000011037156
Diffractometer Number:	0
Goniometer Radius [mm]:	240.00
Dist. Focus-Diverg. Slit [mm]:	100.00
Incident Beam Monochromator:	No
Spinning:	No

1(b) Graphics



2(a) Peak List

Pos.[°2Th.]	Height[cts]	FWHM[°2Th.]	d-spacing[Å]	Rel.Int.[%]	Tipwidth[°2Th.]	Matched by
11.6307	48.56	0.0150	7.60871	8.23	0.0180	01-072-0596
20.8542	124.13	0.1771	4.25968	21.05	0.2125	03-065-0466;01..
26.6610	589.75	0.1968	3.34364	100.00	0.2362	03-065-0466;00..
31.2494	25.46	0.4723	2.86237	4.32	0.5668	01-072-0596
39.5060	28.61	0.2362	2.28111	4.85	0.2834	03-065-0466;01..
45.3856	11.54	0.9446	1.99833	1.96	1.1336	01-072-0596
50.2031	55.70	0.1968	1.81729	9.44	0.2362	03-065-0466;01..
59.9984	35.04	0.2362	1.54191	5.94	0.2834	03-065-0466
68.1453	27.77	0.5760	1.37494	4.71	0.6912	03-065-0466

2(b) Pattern List

Visible	Ref. Code	Score	Compound Name	Displ.[°2Th]	Scale Fac.	Chem. Formula
	03-065-0466	72	Quartz low, syn	0.000	0.962	SiO2
*	00-013-0259	5	Montmorillonite-14A	0.000	9.948	Na0.3(Al,Mg)2..
*	01-072-0596	11	Gypsum	0.000	0.077	Ca(SO4)(H2O..

2(c) Graphics